administrator may encourage individual effort in constructive thought, more consolation is found in the fact that the rare scientific genius cannot be suppressed, though there may be some danger of his applying his originality to financial and routine matters. Familiar indeed are the difficulties which scientific workers find in complying with the regulations controlling their expenditure, or accepting the limitations which a Treasury finds, or may think, necessary to place upon it. Regulations and limitations are regarded as personal insults, for the purpose only of hampering research.

The direction of a group of strongly individualistic investigators, including, it may be, a master mind, and almost certainly several hewers of wood and drawers of water, is no light task. Originality of thought has to be encouraged, but unity of purpose must be maintained in order to achieve the results demanded under the grant. The delinquents in such a group are usually unconscious of any delinquency, as for example the dilettante who flits from one problem to another and believes that he fulfils all obligations if he merely remains on the pay-roll; the brilliant mind that is so undisciplined that it cannot be made to formulate conclusions; or the hard-working procrastinator who dare not put forward his conclusions for fear of omitting some detail. Less deserving of sympathy are the pests who are as quick as a hair-trigger in publishing, and rush into print where more experienced men fear to tread, or the self-selected mouthpiece, who, unwilling to hide his light under a bushel, constitutes himself the agency by which science reaches the average man, and is too often taken at his own valuation. The "professional prominent scientist," another familiar type, at one time formed the popular authority in Washington. His dictum on any new problem was final, but he was more highly reputed by the public than by his colleagues.

A criticism passed on all men of science, not only by Mr. Brooks but also by literary men in Great Britain, relates to the form in which science is presented. The greatest need of the average American, and we may add of the British man of science, is to write clear English. He conveys his message to the people in language they cannot understand, and often he and his colleagues fail to understand one another. The development of such curiously similar types on the two sides of the Atlantic is interesting.

On the outbreak of war the Federal service proved its true worth. The bureaus formed the backbone of war service, for they were immediately available as storehouses of scientific facts and their great corps were quickly turned on to war problems. One result was to reveal the high commercial value of science, with the consequence that the ranks of the Federal service have been most seriously depleted. The best-trained men are now tempted away by the financial prospects of a commercial career, and the second choice only is left to the Government. It is suggested that the change may be due to the lowering of the ideals of the student, for the professor who is compelled to eke out a small salary by taking commercial work or writing text-books for profit, has not the same influence as a "revered master" in research. Without disparaging the high ideal attributed to the student, one is tempted to think that the possibilities of far higher emoluments in commercial service than could be justified in a Government bureau, are the principal inducement.

Pay, however, is not everything. Mr. Brooks reminds us that the young investigator who has obtained a post in the Government service, finds himself a member of a corps of well-trained enthusiastic professional men, whose actions earnestly express public duty and self-sacrifice. He will enjoy among them and in the non-professional societies congenial scientific companionship, and he will realise that the mere mass of such an army of investigators, whose ideals are not less lofty because they include the welfare of mankind, give an inspiration not excelled elsewhere.

A. S.

The Design of Electric Power Stations.

Power House Design. By Sir J. F. C. Snell. (Longmans' Electrical Engineering Series.) Second edition. Pp. xi+535. (London: Longmans, Green and Co., 1921.) 42*s.* net.

THE second edition of this important work will be welcomed by all engineers who are interested in power-station design. The author is the chairman of the Electricity Commissioners; he has been both a distributing and a consulting engineer, and has therefore studied the problem from all points of view. The book is a storehouse of facts which will be of great value to the designer. The general principles which should be followed are laid down and illustrated by clear descriptions of many modern power stations. It is interesting to note that these stations are of very varied design. This is doubtless due partly to the individual experience of the designers, but it also bears out the author's contention that every case must be considered on its own merits, and so the solution applicable in one case may be unsuitable in another. The apparatus inside a power station should be standardised as much as possible, but at the present time it would be inadvisable to attempt to standardise the station itself.

The modern fashion is to concentrate generating lant in large stations. This necessitates having a large supply of circulating water in the neighbourhood and it follows that capital stations are not necessarily situated near a pit's mouth. The most economical engines for driving dynamos are steam-turbines, provided they are worked at a very high vacuum, and in order to secure this we must have a supply of cold water equal to seventy times that required by the boilers. It is this consideration that rules out practically all the colliery sites in this country.

The author thinks that there should be at least two main generating stations to supply a large district. In addition he says that it generally would be found economical to generate part of the load at the points where the demand is greatest. It seems to us that the author does not lay sufficient stress on the fact that the cost of the network of cables required in a large distributing scheme may be 70 or 80 per cent. of the total cost of the undertaking. The main factor in determining the sites, therefore, will be the cost of the cables required. The cost of fuel transport and of the arrangements for circulating water may not vary much for different sites, but in general for a given supply the cost of the requisite cables will vary largely with the position of the power station. For commercial success it is very important that the capital cost of the cables should be as small as possible, and this can only be secured by a close study of the nature of the load required for industrial, domestic, and transport purposes, and then choosing the sites so that the cost of the cables is as small as possible. If the undertaking is to be a success, it is also necessary that the power-houses be capable of continual extension, so that the power available need never be much in excess of the demand. In the early days of the industry many of the stations built were much too large for the demand, and consequently years had to pass before they could pay dividends. It was difficult, therefore, to finance new schemes.

The following interesting comparison is made between the relative value of steam-engine and gas-engine plant. A boiler can easily evaporate 7·5 lb. of steam per lb. of coal consumed; a ton of coal will therefore yield 16,800 lb. of steam. A modern steam-turbine requires 8·2 lb. of steam per brake horse power hour developed. Hence a ton of coal will produce 2049 B.H.P. hours. With a gas producer operating on an average at a thermal efficiency of 75 per cent., a ton of coal of the same calorific value will yield power gas capable of producing 20,160,000 British thermal units. We may assume that on an average a modern gas-engine requires 9500 B.Th.U. per B.H.P. hour, and hence a ton of coal utilised in this way will produce 2122 B.H.P. hours. There is not much difference, therefore, in the amount of the mechanical energy obtained from the coal by the two methods.

It is pointed out that in certain cases an economy in fuel consumption can be obtained by using both steam and gas plant in the same station. The gas plant is almost immediately available, and so can be used to cope with any sudden temporary increases in the load, with consequent economies.

It has often been urged that it would be more economical to extract the potential by-products from the coal first of all and then utilise the resulting fuel products for power purposes. The author makes a careful examination of this procedure. He points out that serious thermal losses are involved in treating coal for by-product recovery and converting into coke or power gas or both. These losses range from 25 to 50 per cent. In the case of a power-house equipped with ammonia recovery producers for gasifying the whole of the coal, the total coal consumption would be from 70 to 80 per cent. greater than that of a corresponding coal-fired station. Considering it from the commercial point of view, he concludes that the prospects of obtaining through the medium of by-product recovery processes bulk supplies of electrical energy at a lower cost than coal firing are practically negligible.

Owing to the increasing attention devoted to the question of fuel conservation during the past twenty years, important developments in the utilisation of thermal products, which were formerly wasted on an enormous scale, have taken place. In particular, the surplus fuel gases produced at iron and steel works have been successfully utilised; for instance, at the important coke-oven works of Messrs. Pease and Partners, Durham, the waste heat is transformed into electrical energy by the supply company, and is "pumped" into the high-tension transmission mains for utilisation throughout the district.

The concluding chapter discusses hydro-electric power-houses, and important stations in America, Mexico, and Sweden are described. The attraction of cheap electric power has caused flourishing towns to spring up in the neighbourhood of some of the American waterfalls, but there are few cases where the hydro-electric power generated is transmitted to a considerable distance.

The author assumes that the reader is an engineer. The general reader, therefore, will occasionally have difficulty in understanding his nomenclature. The importance, for instance, of the load-factor of a station is emphasised, but even the engineer would appreciate being reminded that the load-factor is the ratio of the average load to the maximum possible load. The higher this factor, the more promising the commercial outlook of the station. Later on the notion of the diversity-factor is introduced, defined as the ratio of the sum of the maximum loads on the separate substations to the maximum load at the power-house. It is generally assumed that the higher the diversity-factor, the load-factor remaining the same, the better it is from the commercial point of view. It seems to the writer that these definitions should be examined from a rigorous mathematical point of view to find how far their numerical values can be considered as trustworthy guides of the commercial practicability of a projected scheme.

A "silo" is generally considered to be a pit or cave for storing fodder in the green state. Engineers apparently call a coal-store a "silo," and that at the Greenwich power-house has a capacity of 2000 tons. The coal is fed from the bunkers, into which the silo is divided, into gravity bucket conveyors, which carry it to the overhead bunkers feeding the furnaces. The weight of the coal is checked on weigh-bridges with five-foot dials. It is stated that with a load of 5 tons the maximum inaccuracy is only about 3 lb.!

A. RUSSELL.

Witch-Craft in Western Europe.

The Witch-Cult in Western Europe: A Study in Anthropology. By M. A. Murray. Pp. 303. (Oxford: At the Clarendon Press, 1921.) 16*s*. net.

IN her study of witchcraft in Western Europe Miss Murray has endeavoured to show, first, that the witch-cult was a definite organised religion, and secondly, that it is possible to deduce from the records the character of its ritual. The problem which Miss Murray has set herself is entirely new and has not hitherto been considered, much less attacked.

As regards the evidence upon which Miss Murray's investigations are based, her aim has been to arrive at an impartial statement by quoting the *ipsissima verba* of the witches in their confessions and at their trials as recorded by contemporary chroniclers, all comments of those who compiled the records being omitted. Early accounts of witchcraft, as she points out, are apt to be vitiated by too great credulity or an excess of scepticism.

Exception is not infrequently taken to the evidence of the witches themselves on the ground that it was elicited under torture, but Miss Murray meets this objection by pointing out that in the English trials and in many of the Scottish trials legal torture was not employed. It is true that she is concerned principally with witchcraft in this country and deals with the French evidence only for purposes of elucidation and amplification; much of the French evidence was the result of torture, and even in this country in some of the most important cases torture was employed. In the case of the North Berwick witches, who were accused of a conspiracy against James VI. in which Bothwell was implicated, two were subjected to the ordeal of having their nails pulled out with pincers, pins were stuck into the quick, and they were tortured with the boot. It is to be noted, however, that the confessions, whether elicited under torture or without it, display a remarkable uniformity in detail, although drawn from a wide area and spread over a considerable period of time. This lends strong support to the view that the evidence may be accepted as it stands.

Taking the evidence at its face value, Miss Murray has arrived at the conclusion that the witch-cult was a definite organised religion and, as such, was a survival of the primitive religion of Western Europe. It represents, she holds, the religion of a pre-agricultural people who celebrated their religious festivals in accordance with a pre-solstitial calendar. She argues, reasonably enough, that the wholesale conversions to Christianity in the early days of tribes and peoples were merely superficial and that the bulk of the people continued to follow their old beliefs and to practise their traditional ritual, more or less in secret. If it be conceded that the witches in their accounts of what took place at the Sabbaths were describing, not furtive assemblies for malicious evil practices and unlimited debauchery, but gatherings for performing the rites of an organised religion, their evidence takes on an entirely new significance. Taking this point of view Miss Murray is able to deduce from it the character of the god they worshipped, the nature of the rites, and the organisation by which the religion was carried on.

The god, who was confused with the devil by Christians, was regarded by his worshippers as incarnate in man, woman, or animal. The animal form varied, being sometimes a bull, sometimes a dog, a cat, a horse, or a sheep. The goat, common in France, does not occur in this country. Further investigation of this point might throw light on the early history and distribution of the cult. The god incarnate acted as the leader of the association in which there was an inner circle or council, the "coven," consisting apparently of thirteen individuals. Miss Murray is of the opinion that in certain instances it is possible to identify these leaders, and cites, among others, Bothwell, Joan of Arc, and her companion in arms, Gilles de Rais, the French "Bluebeard." Her suggestion that the god was sacrificed at stated intervals would account for certain peculiar features in the trials, such as, possibly, the line taken by Joan of Arc under examination, and the